Sapphire Advantage: Wavelength Flexibility

Wavelength flexibility – Sapphire lasers are the only visible CW lasers to offer a comprehensive choice of visible wavelengths as well as custom wavelengths.

Advantage: Unlike some alternative technologies, Sapphire lasers can be designed to operate at any wavelength over a wide visible range.
Benefit: Sapphire lasers offer a choice of legacy wavelengths such as the ion laser wavelengths of 488 nm and 568 nm, and the DPSS wavelengths of 532 nm and 561 nm, as well as custom wavelengths for volume OEMs. This means there is always an optimum Sapphire wavelength for any life sciences application, providing higher signal to noise microscopy images with most fluorophores, as well as supporting multi-wavelength applications such as flow cytometry.
How? OPSLs use a tailor-made gain material.

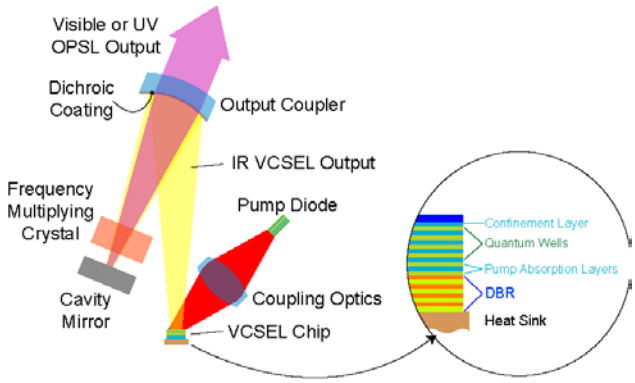

Figure 1: *Some of the key components in an OPSL such as Coherent Sapphire. The wavelength can be arbitrarily chosen by the size and stoichiometry of the InGaAs quantum wells.*

Figure 1 schematically illustrates the main elements of a Sapphire laser. Pump light from a laser diode is re-imaged into the front surface of a VCSEL type chip. This monolithic III-V semiconductor chip contains layers of tertiary quantum wells (InGaAs) alternated between binary (GaAs) layers. These binary layers are optimized to efficiently absorb pump radiation, resulting in a high population of charge carriers. This leads to population inversion and recombination in the quantum wells, which emit near infrared laser light. Behind these absorption/emission layers are several alternating high index and low index layers that act as a low-loss DBR (Distributed Bragg Reflector) mirror optimized for the specific OPSL fundamental. This is efficiently frequency-doubled to visible laser light by an intracavity second harmonic generation (SHG) crystal located near the cavity beam waist.

It is relatively straightforward to customize Sapphire lasers over a wide range of output wavelengths. That's because the emission wavelength of the OPSL is determined primarily by the stoichiometry and physical dimensions of the quantum well structures in the gain chip. For example, by changing the relative proportions of the three constituent elements, an InGaAs based OPSL can be designed and fabricated to produce output anywhere from 700 nm to 1200 nm. Frequency doubling extends this operation through the visible spectrum and beyond (350 nm to 600 nm) – see Figure 2. This wavelength scalability represents a paradigm shift in supporting laser applications. Traditionally applications would select the closest match from available lasers. But Sapphire can be designed to fit the application instead of vice versa.

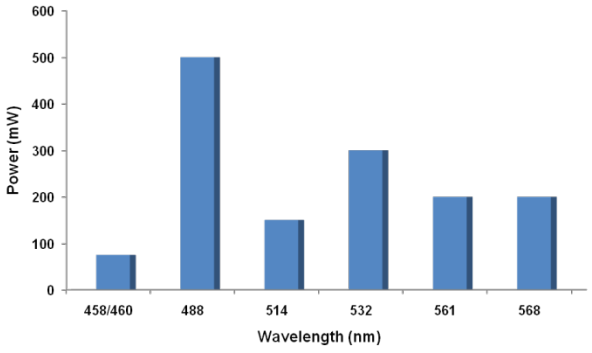

Figure 2: *Sapphire lasers are currently offered at several standard wavelengths, with custom wavelengths available for volume OEMs.*

To optimize laser performance at the chosen wavelength, it's also necessary to maximize the reflectivity of the Bragg reflector in the OPSL and adjust the angle of the doubling crystal. Plus, of course, the cavity optics must be coated to peak their performance at this wavelength.

In free operation, a frequency-doubled OPSL will deliver output with a bandwidth in the 10 nm range. So, in Sapphire lasers, a birefringent filter (BRF) is used whose narrow transmission maximum is smoothly adjusted by rotating about a single axis. This serves two purposes. First, it narrows the laser operation to a handful of cavity modes enabling low-noise frequency-doubling – which will be discussed in a future Sapphire Advantage Note. As a result, the typical bandwidth of a Sapphire laser is 0.1 - 0.2 nm. In addition, the use of a BRF enables Coherent to precisely set the output wavelength of every Sapphire laser, which can be important in applications such as spectroscopy and inspection.

Summary

Sapphire lasers are virtually unique among CW visible lasers in their ability to be scaled to nearly any visible wavelength. The only other technology with this wavelength flexibility is the laser diode, which cannot match Sapphire's power, beam quality and mode stability.